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The Lithosphere and the Asthenosphere in the Mendocino Triple Junction Region

Alan Levander (1), Yongbo Zhai (1), Kaijian Liu (1,2), Jennifer Mackenzie (1), Robert Poritt (3), and Richard Allen (3)

(1) Rice University, Earth Science, Houston, TX, United States (alan@rice.edu, 001 713 348-5214), (2) Applied Physics Program, Rice University, Houston, TX, United States, (3) Earth & Planetary Science, UC Berkeley, Berkeley, CA, United States

The Mendocino Triple Junction (MTJ) region is an excellent natural laboratory for examining the lithosphere-asthenosphere boundary (LAB) in active tectonic settings, since it contains the Gorda oceanic plate subducting beneath North America to form the Cascadia arc. South of the subduction zone is a newly formed transform fault regime where the asthenosphere is at shallow depths in the "slab window". We have developed a 3-D shear velocity model using finite-frequency Rayleigh wave tomography, PdS receiver functions, and ambient noise tomography to better understand the complex lithosphere/asthenosphere structure near the MTJ. The seismic data come from the EarthScope Transportable Array, and the Flexible Array Mendocino Experiment (FAME) conducted by some of the authors. The resulting Vs model (to ∼150 km depth) reveals strong lateral heterogeneity in the lithosphere and asthenosphere, and therefore depth to the LAB.

The LAB is imaged beneath 1) the Gorda plate, 2) the Cascade volcanoes, and 3) the San Andreas transform regime. (1) The subducting Gorda slab is seen as an eastward-dipping high-velocity anomaly, with a well imaged LAB beneath it at depths consistent with plate thickness estimated from the half-space cooling model. (2) Immediately east of the Gorda plate is a large low-Vs zone, which we interpret as the mantle wedge lying beneath the North American Plate and above the Gorda Plate. Under the Cascades, the LAB lies above the mantle wedge at ∼50 km, 10 km deeper than crustal thickness. (3) Near the southern edge of the Gorda plate the LAB is imaged at 80-100 km depth. To the south the LAB shallows rapidly from the base of the subducting lithosphere to depths of < 50 km under the accreted terranes of the transform regime. The rapid shallowing of the LAB is associated with asthenospheric upwelling from beneath the Gorda plate and the Great Valley into what is termed the slab-gap region. Asthenospheric ascent results in small volume decompression melting which is manifest as surface volcanics and crustal intrusions in the transform regime. The LAB depth in this region varies from near the base of the crust beneath volcanic centers to about twice crustal thickness (∼50 km).

In the latter two cases the LAB is associated with partial melt at the base of the lithosphere; by water mediated melting beneath the arc, and by decompression melting beneath the transform regime. If Kawakatsu et al's (2009) model of sheared melt lenses applies to the LAB beneath the Gorda plate, then in the MTJ region, partial melt is responsible for the LAB beneath all 3 regions, but the conditions under which melting occurs are markedly different in each case.